Hydroponic Production

An Educational DVD for High School Agricultural Education

A Senior Project

presented to

the Faculty of the Agricultural Education and Communication Department

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Bachelor of Science

by

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Abstract

The purpose of this project was to create an educational video based upon hydroponic farming. It was created for agricultural educators, in hope high school agricultural teachers would show it in their classrooms. The goal was for students to be able to see a commercial style hydroponic system, and to understand the basic concepts of operation. The video was intended to be supplemented with additional printed information on alternative farming methods. It was not intended to be a sole source of information, but should instead be used to enhance the learning environment for students.

The survey of local high school agricultural teachers asked them to answer the five main questions regarding the video, *Hydroponic Production*: 1.) Do you currently implement hydroponics in your teaching curriculum? 2.) Do you feel that your students would benefit from learning more about hydroponics? 3.) Do you feel that the video, "Hydroponic Production," was educational and easy to understand?

4.) Overall, would you use the video as a supplement for teaching more about hydroponics? 5.) What changes would you recommend to enhance the video and its overall effectiveness?

There were no results to prove that the video would be either effective or non-effective within high school agricultural programs. The teachers that were asked to respond and evaluate the authors' video either did not care or did not have the time to reply. After completing the senior project, gathering the results, and reviewing the findings, the authors determined that the creation of the video could be a great success if the teachers had taken the time to evaluate its usefulness.

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Chapter One - Introduction

Introduction

The idea of hydroponic farming has been in existence for centuries. John Woodward, an English scientist, experimented with plant nutrients in the late 1600's. His goal was to determine how plants obtained their nutrients, whether it was from water or the soil. At that time, farmers generally believed that the soil only provided stability for the plants and roots. This was because during times of drought, all crops would die, regardless of the fertility of the soil (Douglas, 1984, pg. 15-16).

Woodward began his experiment by placing plants in water. Slowly, he added small amounts of soil to the water each day. As he did this, the plants increased in overall health and growth (Douglas, 1984, pg. 15-16).

Due to the advancements of technology in the field of chemistry, scientists began discovering the main nutrients that plants needed to grow strong and healthy, such as nitrogen, phosphorus, and potassium. This led to the discovery of plant growth patterns. Nicolas de Saussure furthered the investigation and published his finding regarding how plants needed mineral substance for optimal growth. Other men such as Jean Boussingault and Julius Von Sachs also continued research on chemical solutions, water nutrient solutions, and growing plants in the absence of soil (Douglas, 1984, pg. 15-16).

In 1929, Dr. William F. Gericke, of the University for California, Berkeley attempted to change laboratory soilless cultivation into real life practical soilless crop production. Gericke was successfully able to cultivate soilless tomato crops, which miraculously reached heights of over twenty-five feet. Because of Dr. Gericke's accomplishments, he went on to name the science of soilless cultivation, hydroponics (Douglas, 1984 pg. 15-16). The word hydroponics is of Greek origin. Hydro means water, and ponos means labor (Mason, 1990, pg. 1). Together, these words mean water-working (Douglas, 1984, pg. 14-15).

Today, hydroponics is the method of growing plants without soil. The roots are grown in either air, water, or a non-soil medium. The water, which is commonly referred to as the nutrient solution, contains a balance of combined nutrients. These nutrients provide the plant with substance for healthy development (Douglas, 1984, pg. 15-16).

There are two types of hydroponic systems. They are classified as water culture and aggregate culture. With water culture, the nutrients are dissolved directly in the water, which is in contact with the roots. Furthermore, the water must be aerated to allow the roots contact with the air to avoid asphyxiation. In aggregate culture, the plants are grown in a solid material such as Rockwool, which is allowed contact with the nutrient solution (Douglas, 1984, pg. 15-16).

There are many advantages of hydroponic farming. The normal growing season of crops is extended because of controlled environments within the greenhouse. This means that produce can be grown during off-season times. For example, lettuce is a cool season crop. With the science of hydroponics, lettuce can be grown and harvested during the summer months as well. This provides the farmer with opportunities for increased yields and profit. Furthermore, this decreases the need for imported produce during off season production months. Because hydroponics is unlike conventional farming where soil is used, tillage and crop rotation is not necessary. This reduces the need for heavy labor and machinery, which in turn, reduces costs, pollution, and reliance on fossil fuels.

Additionally, weeds, pest, and disease problems are reduced because the normal soil is not present. This inhibits weed growth and the natural habitat of invertebrates.

The quality of produce is improved because of the indoor, controlled, environment. External factors such as climate, birds, and other animals are not present in the greenhouse. This helps keep the produce esthetically pleasing. Also, root zone chemistry is easily controlled because salt toxicities are leached out which causes an adjustment in the pH. Salts do not bind chemically to the types of growth media used in hydroponics, so salt build up will not occur. Lastly, hydroponics is sustainable since it continually recycles the water. Because of this, nutrients are conserved and are not leached out into the natural environment and water supply. This reduces the pollution of land and streams. Additionally, many hydroponic farmers use solar panels to capture the sun's energy which powers the farm (Mason, 1990, pg. 12-14).

Hydroponic farming is a very beneficial way of farming; however, it is not free of problems. Some disadvantages associated with hydroponic farming are the initial high costs. The primary construction of the greenhouse and hydroponic system is highly expensive depending on the size and location of the facility. The skill and knowledge needed for operation is pertinent for successful farming. All employees should be trained in the set up, operation, and maintenance of the facility, as well as plant structure, growth, and nutrition Although the amount of disease and pests is limited within the greenhouse setting, any type of disease outbreak can quickly spread because of the close proximity of plants and the nutrient tank, which accesses every plant. The operation must be maintained and cleaned daily for healthy plants free of pests and disease. This is important because of plant sensitivity. Hydroponic plants react more quickly to changes in the growing environment. It is necessary for employees to continually watch the plants for adverse changes in growth (Mason, 1990, pg. 12-14).

Commercial hydroponic farming is especially beneficial in vegetable, herbs, and floral production. Farmers should consider converting some of the land that is currently being used for these crops and grow them hydroponically instead. More land would be available for crops that are not possible to be grown through hydroponic farming, but that are essential for human and animal nutrition. This available land can be used for other crops that are not possible through hydroponic farming, but that are essential for human and animal needs such as corn, wheat, and fruit orchards. In the process, farmers are meeting the demands of the growing population by providing increase yields per acre on a smaller land allotment.

Statement of the Problem

The majority of high schools do not have a hydroponic system because it isn't financially feasible to build and maintain one. Therefore, it was necessary to bring a hydroponic system in video form to the students so they could be fully educated in this aspect of agriculture.

The Importance of the Project

More than ever, school budgets are receiving dramatic cuts. Using a video to demonstrate hydroponics is more cost effective. When adding up the costs of land, construction, maintenance, plant materials, utilities, and insurance, it is easy to see that most schools cannot afford a hydroponic unit. Also, facilitating field trips to hydroponic farms is not feasible because of students' time off campus, bus costs, and even access to hydroponic facilities.

Using a video, in addition to other means of instruction, is beneficial for the student and teacher. Utilizing a video helps the teacher stimulate discussion in the classroom. It gives the ability to stop, start or rewind. By doing this, the teacher allows students the opportunity to engage in discussion and predict possible outcomes that may occur throughout the video. A video is an instructional medium which provides variety to conventional classroom instruction. Implementing a video in classroom instruction stimulates different learning styles, particularly visual and auditory. Furthermore, it gives the teacher ability to replicate the activity found in the video.

Incorporating a video into a classroom environment enhances the students' ability to remain engaged in classroom learning. Not only does a video attract the students' attention, but it also helps them retain information better. A video provides visual representation and information in detail that text and graphics cannot. It illustrates how hydroponics works and provides a real life example.

Educating the public and the future agriculturists is critical for success. This education should consist of all aspects of agriculture, not just conventional farming. The current curriculum in high school agricultural education programs does not encompass hydroponic farming. Therefore, the authors have created a DVD on commercial hydroponic farming. This is to be supplemented with other additional farming alternatives provided by the high school teacher.

Purpose of the Project

The purpose of this project was to create an educational video based upon hydroponic farming. It was created for use in programs of agricultural education at the secondary level. The goal was for students to be able to see a commercial style hydroponic system, and to understand the basic concepts of operation.

Objectives of the Project

- To research and understand commercial hydroponic farming systems and how they combat the issues of urban sprawl.
- To depict the operations at a commercial hydroponic plant
- To develop a storyboard and script
- To create a 5-10 minute video targeted towards high school agricultural students
- To distribute the DVD among high school agricultural teachers within San Luis Obispo County

Definitions of Important Terms

- Hydroponics: Cultivation of plants in nutrient solution rather than in soil
- Urban sprawl: The unplanned, uncontrolled spreading of urban development into areas adjoining the edge of a city
- Arable land: A measure of land capable of being farmed productively
- Sustainable: Capable of being continued with minimal long-term effect on the environment
- Photoperiodism: The response of a plant to the hours of darkness, affecting growth and reproduction.

Stating a Hypothesis

High school agricultural education programs would benefit by the additional learning material on hydroponic farming. Due to lack of funding in most high schools, the video would educate students regarding hydroponic farming without schools having to purchase and maintain their own hydroponic system. This would enhance and broaden the students' learning environment.

Summary

Hydroponics is defined as cultivation of plants in nutrient solution rather than in soil. Hydroponic farming may be used as an alternative source to conventional farming as the population increases and the amount of arable land decreases. Educating about the problems agriculture faces in food productions is essential for positive change. The authors created an educational DVD on commercial hydroponic farming. It will serve as an aid to high school agricultural teachers teaching the hydroponic curriculum to students, especially when there is a lack of financial means for the school to build and maintain their own system.

The DVD will provide the students with an opportunity to see alternative farming methods within the classroom. It will also provide students additional educational material that will help them understand the basic operation and production of commercial hydroponic farming. This will contribute to the learning environment by incorporating visuals to address learning styles.

Chapter Two – Review of Literature

Introduction

A video which depicts a hydroponic system is important to high school agriculture students because with out it they would lack the opportunity to visually understand the concepts of production. Creating a video is an inexpensive and easy alternative to owning and operating a hydroponic facility.

Video Production Concepts

There are three stages of video production, including pre-production, production, and post-production (Millerson, 2001, pg. 192). The important concepts before filming occur during pre-production. This includes the script and storyboard. The script and storyboard is the foundational base that will provide a rough outline to visualize and organize the filming process (Gates, 1999, pg. 50-58). The storyboard illustrates what will be shown in each scene including all visual details. The script depicts what will be said by each individual. Without a detailed script and storyboard, it is difficult to visualize the goals for the video (Bernard, 1990, pg. 167-176).

The second stage of video production is called the production phase. During the production phase, rehearsals and filming occur. This is generally the longest and most time consuming phase because it crucial to have enough footage. Without enough footage, the video may be weak in areas. A general rule to follow is to always over shoot scenes. This is because it is easier to edit your footage down than to not have enough at all. Under certain circumstances, it may be impossible to re-shoot a scene. Therefore, the rehearsal and filming stage is critical for the production of a video (Gates, 1999, pg. 192-212).

The third and final stage of video production occurs during post-production. All of the scene editing, special effects, sound, and music incorporation occur here (Gates, 1999, 147-153). This requires acute attention to detail so that the final video may be of high quality. Editing brings individual scenes together so that the video logically flows from beginning to end (Millerson, 2001, pg 163-170). In order to successfully create a video, the three steps for video production should always be followed. This allows for the producers' ideas to be illustrated within the final video product.

Hydroponic Products

Commercial hydroponic techniques were first applied during the 1930's. Since then, hydroponic technology has improved greatly which is evident by the quality and quantity of products produced (Heyden, 2009). Some of the first crops that were ever grown through commercial hydroponics include: tomatoes, lettuce, peppers, and cucumbers. Presently, there are many more types of produce that is grown through hydroponic farming, including herbs and flowers.

Importance of Site Selection

When constructing a hydroponic system, location should be taken into consideration. The seven key factors that should be examined include climate, day length, brightness, rainfall, humidity, aspect, and wind. Climate determines what can be grown and at what time of year. Even though greenhouses help control the environment of the plants, the climate is still significant for good economics. Plants require the correct amount of darkness in order for them to flower. This is called photoperiodism.

Plants need an appropriate amount of day length in order to reproduce and create fruit. This day length may be natural or artificial, depending on the surroundings and time of year. For example, African Violets need a minimum of sixteen hours of day length for flowering to occur.

Average annual rainfall of the site location may determine the structure of the hydroponic system. The hydroponic system does not need to be covered unless there is more that thirty inches of rainfall. Excessive rainfall will leach the plant of needed nutrients and possibly dilute the nutrient solution. Also, humid locations are suitable for only a limited amount of crops. This is because humid environments increase the incidence of fungal diseases which decrease the pollination of flowers and overall inhibit the fruit from forming.

When choosing the site location of a hydroponic system, the aspect, or slope of the land, is of great importance. The ideal location for a farm would be one that is relatively flat and contains a slight slope. This allows water to drain away from the crop. Farmers do not want a site that is subject to flooding. Furthermore, north-facing slopes are the best location for winter crops because of the sun's direction. This will warm the crop and protect it from wind, frost, and severe cold temperatures. Wind is a detrimental force that can destroy crops and the greenhouse structure. It is suggested that farmers plant trees or shrubs around the greenhouse to act as a windbreak to provide protection. However, a certain amount of wind is needed for correct cross pollination for certain fruit producing plants such as strawberries. Additionally, wind is beneficial to help prevent disease spores from fixing into one spot and infecting a plant. Overall, when choosing a site location, the farmer needs to consider which crop to grow because it needs to match all the above mentioned factors for successful growth (Mason, 1990, pg. 15-16).

Hydroponic Systems

There are many types of hydroponic systems, including Nutrient Film Technique (NFT), deep flow, aeroponics, and substrate systems. The focus of this project is on NFT because it is most commonly used in a commercial setting (Heyden, 2009). NFT is a method of growing plants in a long narrow channel bare rooted. There is a nutrient solution that flows continuously over the roots (Mason, 1990, pg. 36). "The plant grows within a dense mat in the channel and the foliage sits on top, and sometimes is supported by a trellis system (Mason, 1990, pg. 36)." Typically, the channels are made of PVC because it is a water tight material. The channels are then laid on a slope. Gravity pulls the nutrient solution from top to bottom, flowing over the roots. The channels are completely enclosed except for a hole in the top that is needed for the growth of the plant. This creates humidity that provides an environment where the roots can grow and also ensures adequate levels of oxygen in root zone (Mason pg. 36).

The main components used in NFT systems are the growth tray with lid, water pump, air pump, airstone, air tube, growing media, net pots, and a reservoir for the nutrient solution (DIY-Guides, 2009).

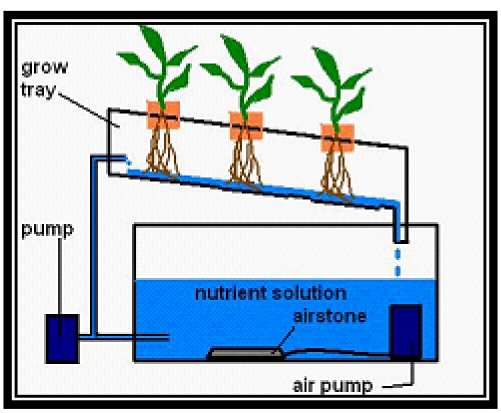


Figure 1: Layout of NFT system
(DIY-Guides, 2009)

"Figure 1 shows the basic components of a NFT hydroponic system. The water enriched nutrient solution is pumped up from the reservoir at the bottom to the top grow tray from one end. The tray is positioned at an angle, allowing the water to flow at approximately 1-3 mm of depth over the bottom surface of the tray. The flow is not too rapid and is slow enough to provide nutrients to the plant in a constant motion. The water is then drained out into the reservoir again on the other end of the tray and recycled. This system gives the plants a constant exchange of the water (DIY-Guides, 2009)."

Growth Mediums

The growing medium is generally determined by the crop, availability, cost, quality, and the type of hydroponic system to be used. The media should be hard enough to be able to support the plant and water infiltration through a long period of time. Soft aggregates should be avoided because they easily break down, decreasing the structure and particle size. This leads to compaction and poor root aeration. Good aggregates are derived from granitic materials. If a hydroponic system is located outside, coarse aggregates with sharp edges should also be avoided because of abrasion to the plant stem, which increases the likelihood of a parasitic attack. In addition, the medium should not contain any toxic materials. For example, sawdust has high levels of salt content. However, if the sawdust has been leached through fresh water it may be used (Resh, 1995, pg. 123-124).

There is no one correct growth medium. Growth mediums may be used alone or in combination with others. Commonly used growth mediums include:

- Vermiculite
- Perlite
- Sand/Gravel
- Scoria/Pumice/Lava Rock

- Rockwool
- Expanded Clay
- Oasis Blocks
- Coconut Fiber
- Peat Moss
- Expanded Plastic Material

(Resh, 1999, pg. 59)

The farmer should carefully consider all options and choose one, which best suites the crop production. Another, alternative is to create a combination media that is unique for the plant's needs. When creating a combination of materials, choose a main medium that is well suited for the plant and other secondary mediums that provide other qualities that the main medium lacks in. For instance, granitic material increases aeration and decreases the likelihood of root compaction. However, it does not contain organic material so a media such as sphagnum peat moss should be added. Peat moss provides a high cation exchange capacity as well as increased water holding capacity. Together, they form an ideal growing medium (Resh, 1999, pg. 59).

The farmer should carefully consider all options and choose one which best suites his crop production. When creating a combination of materials, choose a main medium that is well suited for the plant and other secondary mediums that provide other qualities that the main medium lacks in. For instance, granitic material increases aeration and decreases the likelihood of root compaction. However, it does not contain organic material so a media such as sphagnum peat moss should be added. Peat moss provides a high cation exchange capacity as well as increased water holding capacity. Together, they form an ideal growing medium (Resh, 1999, pg. 59).

Regardless of the growing medium, the plant requires essential nutrients that are provided by the nutrient solution. According to Howard Resh, the author of *Hydroponic*

Food Production, all of the essential elements are provided to the plants via dissolved fertilizer salts in water, which is commonly known as the nutrient solution (Resh, 1999, pg. 59). Essential macronutrients include nitrogen, phosphorus, potassium, sulfur, magnesium and calcium. Furthermore, micronutrients are comprised of iron, boron, zinc, molybdenum, manganese, and copper. Although micronutrients are only needed in small quantities, both macro and micronutrients are all required for optimal plant growth.

Hydroponics: Feeding the Future

The population of the world continues to grow at unprecedented amounts. As the population increases, the lack of available arable land decreases. Consequently, farmers are encountering many problems increasing yields of production per acre-foot of land. Therefore, these situations might increase the cost of food because of the high demand and low supply in coming years. Hydroponics could potentially be a solution. "Yields with hydroponic techniques have averaged around twenty to twenty-five percent higher than conventional soil cultivation. However, over a number of years the yield of hydroponically grown tomatoes can be more than double that of soil based systems due to the reduced turnover time between crops, better nutrition, and crop management. Additionally, commercial hydroponic growing techniques are also less demanding of chemicals for root zone sterilization and control of pests, weeds, etc" (Heyden, 2009). This new technique provides the opportunity to bring locally grown, fresh produce to large urban areas, where it would otherwise be impossible.

Hydroponic farming allows people to have the ability and option to grow food in places where agriculture is not typically feasible. For example, hydroponic systems can utilize unused rooftops for large buildings in urban settings to grow produce. Taking advantage of wasted space on empty rooftops will bring locally grown, fresh produce to consumers at a reduced cost. Prices are lowered due to decreased packing, storage, transportation, and marketing costs. This also decreases the dependence on an imported food supply. As the population of the world increases, hydroponics is going to be one of the only ways to feed large populations. Much of the world's valuable arable farmland is slowly consumed by asphalt, construction, and pollution. Therefore, farming through hydroponics will be necessary to feed people.

Chapter Three – Methods and Materials

Methods and Materials: A Step by Step Guide

The authors of the project first visited a commercial hydroponic facility at California Polytechnic State University, San Luis Obispo. Here the different hydroponic designs and equipment commonly used in the industry were examined. The authors spoke with the facility advisor overseeing the hydroponic greenhouse to determine the issues and problems that growers face. Also, the authors were able to determine what type of growing mediums and plant nutrients were being used to produce commercial hydroponic lettuce.

The authors then developed a storyboard by creating a template which included the shot number, camera angle, description, and visual that would be used while filming. Then, a script was developed to coincide with the storyboard to include all of the information that the authors had previously researched. Once this was completed, filming began. All equipment required was reserved through Cal Poly Media Distribution Services, and the filming took place on the Cal Poly campus.

Finally, after filming enough footage, the editing process began. The authors completed all scene modifications, voice-overs, special effects, and compilation of the video. Once the video was completed, the DVD was burned, copied, and uploaded onto YouTube.com. It was then sent to agricultural high school teachers in San Luis Obispo, Morro Bay, Arroyo Grande, Templeton, Atascadero, Paso Robles, and Clovis, California along with a survey to evaluate its effectiveness.

Chapter Four – Video Production

***Hydroponic Production* Video Storyboard**

Shot # 1

Camera Angle

Visual

Description:

Introduction

- Title
- Producers
- Location
- Date

Shot # 2

Camera Angle

Visual

Description:

What is hydroponics?

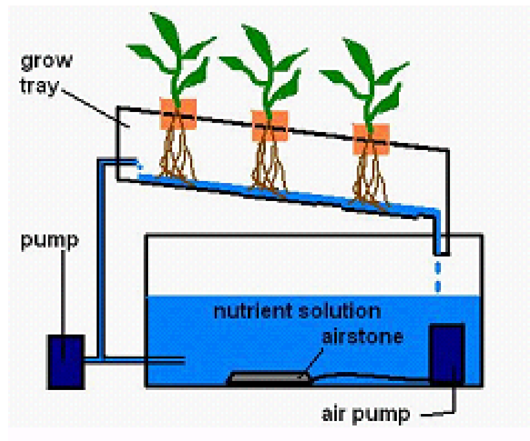
- Method of growing plants without soil
- Roots are grown in either air, water, or a non-soil medium
- Water, which is commonly referred to as the nutrient solution, contains a balance of combined nutrients
- These nutrients provide the plant with substance for healthy development

Shot # 3	Camera Angle	Visual

Description:

Nutrient Film Technique

- NFT
- Located in a green house
- Most commonly used in commercial setting
- Method of growing plants in a long narrow channel bare rooted (no soil)
- Nutrient solution that flows continuously over the roots
- Channels made of PVC (water tight)
- Gravity pulls the nutrient solution from top to bottom, flowing over the roots(degree of slope)
- Other systems include deep flow, aeroponics, and substrate systems



Shot # 4	Camera Angle	Visual

Description:

Components of an NFT system

- Grow tray with lid
- Water pump
- Air pump
- Air stone
- Air tube
- Reservoir for the nutrient solution

Shot # 5	Camera Angle	Visual

Description:

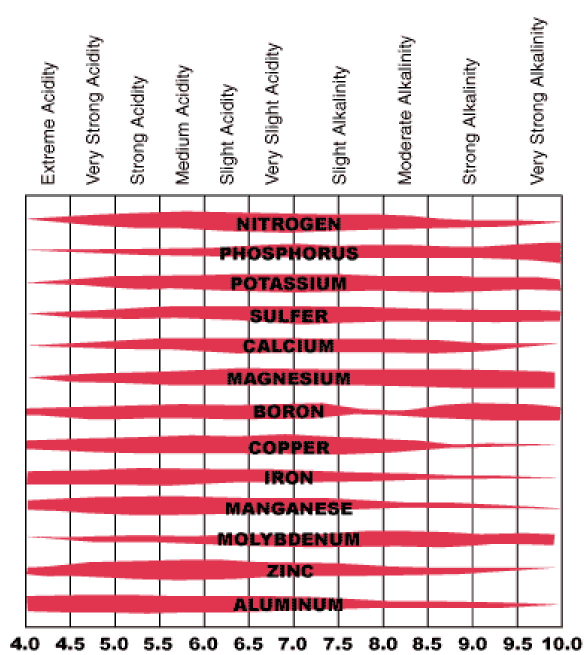
Location

- Consider the following 4 factors:
- Climate
    - Economics
    - Determines what can be grown and during what season
    - Temperature of greenhouse for lettuce
- Light intensity and duration
    - Number of foot candles required (SD vs. LD)
    - Need for reproduction
    - Artificial or natural (season dependent)
- Humidity
    - Root growth
    - Ensure adequate levels of oxygen in root zone
    - Relative humidity
    - North facing slope increases light during Winter months

Shot # 6	Camera Angle	Visual

Description:

2. Nutrient Solution
    - Macronutrients
    - Micronutrients



Shot # 7	Camera Angle	Visual
Description:		

Conclusion – Hydroponics: Feeding the Future

- As population increases, arable land decreases
- With conventional farming, farmer struggle to increase yields of production per ac-ft.
- High demand for food and low supply
- Hydroponics produce 25% higher yields
- Less demanding of chemicals
- Provides locally grown produce to large urban areas
- Ability to grow food in places where agriculture is not feasible (rooftops)
- Lower prices due to local packing, storage, transportation, and marketing costs
- Decreases dependence on imported food supply

Shot # 8	Camera Angle	Visual
Description:		

Credits

- Special thanks
- Bloopers

***Hydroponic Production* Video Script**

Chelsey: Hi, welcome to *Hydroponic Production.* I'm Chelsey Brown, and this is Lindy Mattice. Today, we're here to introduce you to the fundamentals of hydroponics.

Lindy: Due to increasing population and urban sprawl, California's prime agricultural land is quickly decreasing. Hydroponics is one of the few solutions to produce more food on less land.

Chelsey: In this video you will learn the general concepts of a hydroponic system.

Chelsey: The beginning of any hydroponic system begins with a well maintained greenhouse. Within the greenhouse, the hydroponic system and plants are under a controlled environment which protects them from harsh weather conditions.

Lindy: Nutrient Film Technique, or NFT, is most commonly used in a commercial setting is a method of growing plants in a long narrow channel bare rooted. There is a nutrient solution that flows continuously over the roots. Typically, the channels are made of PVC which is water material, which is then laid on a slope. Gravity pulls the nutrient solution from top to bottom, flowing over the roots. The channels are completely enclosed except for a hole in the top that is needed for the growth of the plant. This creates humidity and ensures adequate levels of oxygen in root zone.

Chelsey: The climate and nutrient solutions are controlled by the computer system seen here. This creates a perfect growing environment needed for your crops.

All of the essential elements, both macro and micronutrients, are provided to the plants via dissolved fertilizers in water. This is commonly known as the nutrient solution. All of the ingredients needed for the nutrient solution are stored here and are automatically mixed by the computer system.

Lindy: The water enriched nutrient solution is pumped up from the reservoir tank to the grow tray at one end of the NFT system. The nutrient solution flows approximately 1-3 mm depth over the bottom surface of the tray. The flow is not too rapid and is slow enough to provide nutrients to the plant in a constant motion. The nutrient solution is then drained out into the reservoir again on the other end of the tray and recycled. This system gives the plants a constant exchange of the solution.

Chelsey: The growing medium is generally determined by the crop, and the availability of materials. The media should be hard enough to be able to support the plant and water infiltration through a long period of time. Soft aggregates should be avoided because they easily break down, decreasing the structure and particle size. This leads to compaction and poor root aeration.

Growth mediums may be used alone or in combination with others. Commonly used medium include rockwool, oasis blocks, coconut fiber, and peat moss. The farmer should carefully consider all options and choose one, which suites his crop production needs.

Lindy: Hydroponic farming allows people to have the ability and option to grow food in places where agriculture is not typically feasible. As the population of the world increases, hydroponics is going to be one of the only ways to feed such a large population. Much of the world's valuable arable farmland is slowly consumed by asphalt, construction, and pollution. Therefore, farming through hydroponics will be necessary to feed hungry people.

Chapter Five – Conclusions and Recommendations

Conclusions

Based on the findings, the conclusions of this study were:

1. The authors' hypothesis stated that high school agricultural education programs would benefit by the additional learning material on hydroponic farming. This would enhance and broaden the students' learning environment. This hypothesis was not proven either true or false due to no responses from teachers.
2. The authors believed that the video, *Hydroponic Production*, would be a valuable asset to any high school agricultural program. However, since no feedback was provided, there was no definite conclusion.

Recommendations

If this study was to be conducted again, the authors recommended the following:

1. If the authors had the ability to do the surveying process over, they would have distributed the video a week earlier to allow more time for evaluation from the teachers.
2. Instead of distributing the video and survey via email, the authors would have hand delivered the DVDs and surveys to each teacher. This would have ensured responses and feedback from every teacher.
3. In addition to sending a reminder via email, the authors would have also made a phone call to each teacher.

After completing the senior project, gathering the results, and reviewing the findings, the authors determined that the creation of the video could be a great success if the teachers had taken the time to evaluate its usefulness. Upon completing the video, the authors also noted that another student in the agricultural education department should make a second video to expand on the original senior project. The second video would allow for further discussion and exploration about commercial hydroponic farming. Additionally, the video could meet the needs of high school agricultural programs by enhancing their crop science curriculum. Through the video, students could learn the advantages and disadvantages of hydroponic farming. Finally, it could also teach students that hydroponics is an alternative source to conventional farming which is needed due to the increase in population and urban sprawl.

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Appendices

Appendix A: Storyboard Template

Shot #	Camera Angle	Visual
Description:		

Appendix B: Survey Response Letter to High School Agricultural Teachers

Dear AG Teachers,

As Agricultural Education students at Cal Poly, we are required to participate in a senior project which lasts three quarters long. We have chosen to research hydroponics and how it is used within high school AG curriculum. The main product of our project has been the creation of a video that may be used to help teach high school students more about commercial hydroponics.

We ask that you please take the time to watch the four minute video found here. Following the video, there is a five question anonymous survey which will help us further gage the effectiveness of the video. We would appreciate all responses by Monday, June 7th.

Thank you very much for you time and help with our project. We really appreciate your support and feedback. If you have any further questions, please email Lindy at lkirk@calpoly.edu or by phone, 805-***-****. Thanks again!

Sincerely,

Lindy Mattice and Chelsey Brown
California Polytechnic State University, San Luis Obispo

Appendix C: Survey to High School Agricultural Teachers

1. Objective

The purpose of this project was to create an educational video based upon hydroponic farming. It was created for agricultural education, so that high school agricultural teachers would show it to their classrooms. The goal was for students to be able to see a commercial style hydroponic system, and to understand the basic concepts of operation. It should be noted that the video was intended to be supplemented with additional printed information on alternative farming methods. It was not intended to be a sole source of information, but should instead be used to enhance the learning environment for students.

2. Survey

1. Do you currently implement hydroponics into your teaching curriculum?

- ☐ Yes
- ☐ No

2. Do you feel that your students would benefit from learning more about hydroponics?

- ☐ Yes
- ☐ Maybe
- ☐ No

3. Do you feel that the video, "Hydroponic Production," was educational and easy to understand?

- ☐ Yes, defiantly
- ☐ Yes overall; somewhat unclear/vague
- ☐ Not sure
- ☐ No; more confusing than helpful and/or left out pertinent information

4. Overall, would you use the video as a supplement for teaching more about hydroponics?

- ☐ Yes
- ☐ Maybe
- ☐ No

5. What changes would you recommend to enhance the video and its overall effectiveness?

Appendix D: Survey Reminder Letter to High School Agricultural Teachers

Dear AG Teachers,

As a reminder, please take the time to view our four minute video found here.

Following the video, we ask that you would please take a five question anonymous survey.

Thank you very much for you time and help with our project. We really appreciate your support and feedback. If you have any further questions, please email Lindy at lkirk@calpoly.edu or by phone, 805-***-****. Thanks again!

Sincerely,

Lindy Mattice and Chelsey Brown
California Polytechnic State University, San Luis Obispo